(3) "surfing maneuvers": those maneuvers capable of performance on a surfboard which occur under ocean like hydrodynamic conditions, including deep water flows with the appropriate ocean approximating flow characteristics. Surfing maneuvers include riding across the face of the surface of water on a surfboard, moving down the surface toward the lower end thereof, manipulating the surfboard to cut into the surface of water so as to carve an upwardly arcing turn, riding back up along the face of the inclined surface of the body of water and cutting-back so as to return down and across the face of the body of water and the like, e.g., lip bashing, floaters, inverts, aerials, 360's, etc.

(4) "water skimming maneuvers": those maneuvers which can be performed on shallow water flows including "surfing like maneuvers" (i.e., similar to those described in "surfing maneuvers above) as well as, other activities or other types of maneuvers with differing types of vehicles e.g., inner-tubes, bodyboards, etc.

(5) "body of water": a volume of water wherein the flow of water comprising that body is constantly changing, and with a shape thereof at least of a length, breadth and depth sufficient to permit surfing or water skimming maneuvers thereon as limited or expanded by the respective type of flow, i.e., deep water or shallow water.

(6) "conform (conformed, conforming)", where the angle of incidence of the entire depth range of a body of water is (at a particular point relative to the inclined flow forming surface over which it flows) predominantly tangential to said surface. Consequently, water which flows upon an inclined surface can conform to gradual changes in inclination, e.g., curves, without causing the flow to deflect. As a consequence of flow conformity, the downstream termination of an inclined surface will always physically direct and point the flow in a direction aligned with the downstream termination surface. A conformed water flow is a non-separated water flow and a deflected water flow is a separated water flow, as the terms separated and non-separated are known by those skilled in the art.

(7) "equilibrium zone": that portion of an upwardly inclined body of water wherein a rider is in equilibrium depending on the one hand, on an upwardly directed force ascribable to the drag or resistance of the riders vehicle or body dipped into the stream of water and,

on the other hand, on a downwardly directed force produced by the component of the weight of the rider in a direction parallel with the inclined water forming means.

P, B

(8) "supra-equidyne area": that portion of a body of water above the equilibrium zone wherein the slope of the incline is sufficiently steep to enable a rider to overcome the upwardly sheeting water flow and slide downwardly thereupon.

P, B

(9) "sub-equidyne area": that portion of a body of water below the equilibrium zone that is predominantly horizontal. In the sub-equidyne area a rider cannot achieve equilibrium and will eventually (due to the forces of fluid drag) be moved back up the incline.

P

N'

One object of the present invention is to improve upon the parent invention by providing a flow forming surface upon which a shallow water flow can produce a body of water that is similar to the kind prized by surfers, i.e., a tunnel wave, which has a mouth and an enclosed tunnel extending for some distance into the interior of the forward face of the wave-shape. Such improvement is hereinafter referred to as the "Shallow Flow Tunnel Wave Generator." Heretofore, tunnel waves have only been available to surfers in a natural or deep water flow environment. The subject invention, through proper configuration of a flow forming surface and adequate shallow water flow characteristics (e.g., velocity, turbidity, depth, direction, etc.), can produce wave forms that have similar appearance and ride characteristics as "real" tunnel waves subject to certain ride conditions, e.g., limitation on surfboard fin size. However, the significant cost savings attributive to shallow flow construction and reduced energy consumption outweigh any limitations that may be imposed.

The parent invention also provided for a stationary non-breaking upwardly inclined deep water flow shape for beginners. The subject invention will also improve upon this embodiment of the parent invention through the use of shallow water flow technology. Such improvement is hereinafter referred to as the "Shallow Flow Inclined Surface." In addition to the significant advantage or reduced cost, additional advantages to the shallow water improvements described above include, increased safety due to reduced deep water pool depth, reductions in water maintenance due to decrease in volume of water treated, and the opportunities to create novel water sports, e.g., flowboarding or inner-tube "bumper cars".

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A second object of the subject invention is to provide a flow forming means (hereinafter referred to as the "Connected Structure") comprised of a substantially horizontal flat surface (the sub-equidyne area) that transitions by way of a radial concave arc (the equilibrium zone) connected to the supra-equidyne area (e.g., the inclined plane or tunnel wave generator). The Connected Structure facilitates a riders ability to maximize his forward speed by the riders own efforts of "pump-turning", hereinafter more fully described as the "Acceleration Process". Without benefit of said Connected Structure such increased speed would not be available. The Connected Structure encompasses the complete spectrum of surface flows and wave shapes desired by wave-riding and water skimming enthusiasts. Beginning at one extreme with a flat incline, and progressing by introduction of an increasing array of surface curvatures from the horizontal to the vertical combined with varying attitude and inclination of said surface relative to an upward (or downward, as the case may be) flow of water that culminates at the other extreme in a tunnel wave shape. A significant feature of the Connected Structure is how its unique configuration can dramatically improve the performance parameters of the parent invention's inclined Surface embodiment. The parent invention hereto permitted conventional surfing maneuvers; however, its structure did not optimally facilitate the generation of forward speed with which to perform such maneuvers. The "Acceleration Process" as now enabled by the Connected Structure improvement allows such forward speed to be attained.

A third object of the subject invention is to solve the transient surge problems associated with the ride start-up and rider induced flow decay upon upwardly inclined flow surfaces. This solution results by lowering the downstream boundary area of the inclined flow forming surface at an angle so as to create a maximum height ridge line of decreasing elevation to facilitate self-clearing of undesirable transitory surges. This improvement is hereinafter referred to as the "Self-Clearing Incline."

A fourth object of the subject invention and a novel ramification to the "Self-Clearing Incline" occurs by extending the inclined flow forming surface and associated ridge line of the downstream boundary area to an increased elevation. If such increase in elevation is in excess of the net total head flow necessary to scale this new increase in elevation, then the flow will form a hydraulic jump and the sub-critical water thereof will spill down the upwardly sheeting flow in the manner of a spilling wave. This improvement is hereinafter called the "Inclined Riding Surface with Spilling Wave"). The spilling wave

phenomena can also be incorporated into the other embodiments as described herein. A corollary improvement to any spilling wave application is a properly configured vent system to handle the water which spills back down the flow forming surface. If such water remained unvented, it would eventually choke the entire flow. Consequently, to maintain a steady state condition, to the extent that new water flows into the system, then, an equal amount of old water must vent out.

A fifth object of the subject invention is to improve by way of combination the tunnel and inclined flow forming surfaces, as well as, creation of an intermediate "spilling wave" that works in combination with the inclined flow surface. This embodiment is hereinafter referred to as the "Omni-Wave". A feature of the Omni-Wave embodiment is its unique flow forming shape can permit (by way of a progressive increase of the net head of the sheet flow) the transformation of a sheet of water flow from a stationary "spilling wave" along the entire forming means, to a transitional "spilling wave" with inclined surface flow, to the final inclined surface flow and tunnel wave shape. This method is hereinafter referred to as the "Wave Transformation Process". The Omni-Wave and the Wave Transformation Process will offer an improved environment for the performance of surfing and water skimming maneuvers.

A sixth object of the present invention is to provide an apparatus that will enable riders to perform surfing and water skimming maneuvers in a format heretofore unavailable except by analogy to participants in the separate and distinct sports of skateboarding and snowboarding, to wit, half-pipe riding. In this regard, the present invention comprises a method and apparatus for forming a body of water with a stable shape and an inclined surface thereon substantially in the configuration of a longitudinally oriented half-pipe. Such improvement is hereinafter referred to as the "Fluid Half-Pipe." A corollary improvement to the Fluid Half-Pipe is to provide an apparatus that permits an increased throughput capacity by increasing the depth of the Fluid Half-Pipe in the direction of its length. This increase in depth will have the added benefit of causing a rider to move in the direction of fall and facilitate his course through the ride.

The final object of the present invention is the positioning of dividers within a Fluid Half-Pipe or Inclined Surface as described above and to prevent a "jet wash" phenomenon that can result in loss of a rider's flow. This "jet wash" phenomenon occurs when a rider who is positioned in the equilibrium or supra-equidyne area of a thin sheet flow gets his flow of water cut off by a second rider positioned with priority to the line of

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flow. The cutting off of water occurs in thin sheet flow situations due to the squeegee effect caused by the second rider's skimming vehicle. The improvement aids in preventing adjacent riders from cutting off their respective flows of water. Such improvement is hereinafter referred to as "Sheet Flow Dividers."

Other objectives and goals will be apparent from the following description taken in conjunction with the drawings included herewith.

Brief Description of the Drawings

FIGURE 1 is a profile view of a Tunnel "Wave" Generator configured for shallow waterflows.

FIGURE 2 is a contour map of Tunnel "Wave" Generator as set forth in FIGURE 1.

FIGURE 3 is a plan view of the range of horizontal attitude with respect to the direction of water flow that the wave generator (as set forth in Figure 1) can take and still form a tunnel wave.

FIGURE 4 is a view in profile of a typical cross-section disclosing the range of inclination of the forward face of the wave generator (as set forth in Figure 1) with respect to the direction of water and orientation to the vertical.

FIGURE 5 depicts a rider on the Tunnel Wave Generator.

FIGURE 6 is a profile view of the inclined surface.

FIGURE 7 is a cross-sectional view of the inclined surface as shown in FIGURE 6.

FIGURE 8 depicts a rider on the Inclined Surface.

FIGURE 9a is a profile view of the Connected Structure.

FIGURE 9b is a cross-section of FIGURE 9a.

FIGURE 10 depicts a surfer riding an Inclined Surface as improved by the Connected Structure and who is taking advantage of the acceleration process.

FIGURE 11a is a profile view of the Self Clearing Incline.

FIGURE 11b is a cross-section of FIGURE 11a.

FIGURE 12 is a contour map of the Self-Clearing Tunnel Wave.

FIGURE 13a, FIGURE 13b, and FIGURE 13c are three views in profile that illustrate in time lapse sequence a self-clearing Inclined Surface.

FIGURE 14a and FIGURE 14b illustrate in time lapse sequence the self-clearing Tunnel Wave.

FIGURE 15 is a profile view of the Omni-Wave.

FIGURE 16a depicts the Omni-Wave with a spilling wave formed along its entire front face.

FIGURE 16b depicts the Omni-Wave with a clear inclined surface and a spilling wave.

FIGURE 16c depicts the Omni-Wave with a clear inclined surface and a Tunnel Wave.

FIGURE 16d depicts a Body Boarder performing water skimming maneuvers and a surfer performing surfing maneuvers on the Omni-Wave.

FIGURE 16e depicts a knee boarder riding the spilling wave.

FIGURE 16f depicts a water skier on the inclined surface and an inner-tube rider on the spilling wave.

FIGURE 17 shows in profile view of a novel embodiment for water sports - the Fluid Half-Pipe. 13

FIGURE 18a shows an elevation of a typical Fluid Half-Pipe.

FIGURE 18b shows an elevation of a Fluid Half-Pipe with modified flow forming bottom to assist in capacity and rider through put.

FIGURE 19 illustrates in profile view an improvement to the Fluid Half-Pipe to assist in increased through put capacity.

FIGURE 20 shows dividers in a shallow flow to avoid flow "jet wash."

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Detailed Description of the Subject Invention

Because the original application, the continuation of the original application and the subject invention are operated in water, and many of the results of its passage there-through, or the propelling of water against the wave or flow forming means thereof, are similar to those caused by a boat hull, some of the terms used in the descriptions hereto will be nautical or marine terms; likewise, from the perspective of physical water dynamics, some of the terms used herein will be hydraulic engineering terms; and finally, from the perspective of ride operation and function, some of the terms used herein will be terms as used in the sport of surfing; all such terms constitute a ready-made and appropriate vocabulary which is generally understood by those skilled in the art. To the extent that there are special terms, then, those terms are further defined herein.

Further, it will be understood by those skilled in the art that much of the description of structure and function of the wave generator and inclined surface of the

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original application and its continuation application may apply to the embodiments of the subject invention, to the extent used by this application, Therefore, the descriptions of the flow forming means/wave generator hull and inclined surface of the prior applications 14 should also be read in conjunction with Figures 1-20. However, to the extent there are any differences or discrepancies between the description and teaching of the prior applications and the subject invention, the description and teaching of the subject invention shall prevail.

Except where specifically limited, it is to be understood that the embodiments as described herein are to function in both deep and shallow flow environments. Furthermore, that the flow (except where noted) is to be super-critical (i.e., according to 22,29 the formula $v > \sqrt{gd}$ where v = velocity, g = acceleration due to gravity ft/sec^2, d = depth of the sheeting body of water).

Description of Shallow Flow Tunnel "Wave" Generator

Turning now to Fig. 1 (isometric view) and Fig. 2 (contour map) there is illustrated a Tunnel "Wave" Generator 30 similar to the generator of prior application, however, improved to serve in a shallow water flow. Plan-sectional lines as revealed in Fig. 1 and contour lines as revealed in Fig. 2 are solely for the purpose of indicating the three-dimensional shape in general, rather than being illustrative of specific frame, plan, and profile sections. Tunnel Generator 30 is comprised of a stem 31, a front face 32, a stern arch 33, an upstream edge 34 running from stem 31 to stern arch 33 and acting as the upstream perimeter of front surface 32, a downstream edge 35 running from stem 31 to stern arch 33 and acting as the downstream perimeter of front face 32, back surface 36, and sub-surface structural support 37. Front surface 32, bounded by upstream edge 34, downstream edge 35 and stern arch 33 is that feature of Tunnel Generator 30 which effectively shapes its tunnel "wave." Moving in a direction as indicated by arrow 38, super-critical shallow water flow 39 originating from a water source (not shown) moves in a conforming flow upward over the front face 32 to form an inclined body of water in the shape of a tunnel "wave" (not shown) upon which a rider (not shown) can ride. Back surface 36 is sufficiently smooth and with transitions analogous to a conventional waterslide such that a rider (not shown) could safely be swept over or around Tunnel Generator 30 to a termination pool or area (not shown) to properly exit. The outside dimensions of the flow forming front face 32 of Tunnel Generator 30 are capable of a broad range of values which depend more upon external constraints, e.g., financial

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resource, availability of water flow, etc., rather than specific restrictions on the structure itself. However, for purposes of scale and not limitation, in order to form a tunnel "wave" of adequate size to fully accommodate an adult user, the outside dimensions of Tunnel Generator 30 should be approximately 1 to 3 meters in height and 3 to 12 meters in length.

At least three characteristics of front face 32 of Tunnel Generator 30 influence the size, shape and angle of the tunnel "wave," and each of them interacts with the others:

A. its shape (Fig. 1 and 2);

B. its attitude - its horizontal position or angle with respect to the direction of water flow (Fig. 3); and

C. its inclination - its vertical position or angle with respect to the direction of water flow (Fig 4).

Each characteristic of front face 32 is now discussed in detail.

A. <u>Shape</u>

Front face 32 of Tunnel Generator 30 has a complex shape comprised of concave curvature, both vertically and horizontally, as indicated generally by the Fig. 1 plan sections lines and Fig. 2 contour lines. Such lines are substantially but not specifically illustrative of the range of possible shapes, as will now be explained more fully:

1. Vertically:

   a. the shape of the vertical curvature can be:

      (1) substantially a simple arc of a circle; or

      (2) preferably an arc of a more complex changing curve, e.g.:

         (a) ellipse;

         (b) parabola;

         (c) hyperbola; or

         (d) spiral.

If a changing curve, it preferably changes from an opening curve (i.e., the ascending water encounters an increasing radius as it ascends front face 32) at stem 31 through a transition point 40; to a closing curve (i.e., the ascending water encounters a decreasing radius as it ascends front face 32) from transition point 40 to stern arch 33. A critical feature of Tunnel Generator 30 is that commencing at transition point 40, front face 32 begins to curve past the vertical. Curvature past the vertical from transition point 40

towards the stern arch 33 gradually increases from 0 to a maximum of 30 degrees. 10 degrees if preferred.

2. Horizontally

a. The shape of the horizontal curvature can be:

(1) substantially an arc of a circle; or

(2) preferably, a portion of a more complex, changing, curve, e.g.:

(a) ellipse;

(b) parabola;

(c) hyperbola; or

(d) spiral.

B. Attitude

As disclosed in Fig. 3, the horizontal attitude of front face 32 with respect to direction 38 of water flow can vary only within certain limits otherwise the "tunnel" will not develop. Since front face 32 has concave curvature of varying degrees along its horizontal axis, for purposes of orientation an extension of upstream edge 34 is used to indicate varying horizontal attitudes of front face 32 therefrom. Accordingly, upstream edge 34 can vary from substantially perpendicular to the direction 38 of water flow to an angle of approximately 35 degrees, as shown.

C. Inclination

As disclosed in Fig. 4, the inclination of the front face 32 with respect to the direction 38 of water flow is also limited, otherwise the tunnel will not be developed. Two factors are important with respect to inclination, first, the change in angle of incline relative to the depth of the water must be sufficiently gradual to avoid separation of flow lines/deflection. Second, the angle of release (as defined by a line tangent to front face 32 at downstream edge 35 when compared to the vertical) must be past the vertical as shown. Amounts past vertical may vary, however, a preferred amount is 10 degrees.

At least two other factors effect the size and shape of tunnel wave formation, i.e., flow velocity and water flow depth. The velocity of the water over Tunnel Generator 30 has a wide range, dependent upon the overall size of the Tunnel Wave Surface and the depth of water. In general, the flow is to be super-critical (i.e., according to the formula $v>\sqrt{gd}$ where v = velocity, g = acceleration due to gravity ft/sec^2, d = depth of the

sheeting body of water). However, velocities in excess of that which is at a minimum necessary to achieve supercritical velocity are sometimes desired, e.g., to provide sufficient momentum transfer to support the weight component of a given rider, and to achieve the vertical heights required to form a tunnel "wave."

The depth of the water is primarily a function of the minimum necessary to permit a tunnel "wave" to form at a given height, and simultaneously enable the flow of water to support (via momentum transfer) the weight component of a contemplated range of users. Because of the operational requirements of momentum transfer, the depth of the water has direct relationship to the velocity of the water, i.e., the higher the velocity of flow, the lower the requisite depth. Since this embodiment is limited to shallow flows, the depth of water will range from approximately 2 to 40 centimeters.

Tunnel Generator 30 can be fabricated of any of several of well known materials which are appropriate for the use intended. Concrete; formed metal, wood, or fiberglass; reinforced tension fabric; air, foam or water filled plastic or fabric bladders; or any such materials which will stand the structural loads involved. A preferred embodiment includes a thick foamed plastic covering to provide additional protection for the riders using the facility.

Theoretically, no pool or water containment means is required for Tunnel Generator 30, in that the flow from a suitable flow source (e.g., pump and nozzle, fast moving stream or elevated reservoir/lake) is all that is required. However, where water recycling is preferred, then, low channel walls can be constructed to retain the flowing water with a lower collection pool, recycling pump and appropriate conduit connected back to the upstream flow source. The area of channel containment need be only large enough to allow the performance of appropriate water skimming maneuvers, since the curling water of the tunnel wave would remain more or less stationary with respect to the containment structure. Thus, such a structure could be constructed even in a backyard.

From the description above, a number of advantages of Tunnel "Wave" Generator 30 becomes evident:

(a) The energy required to produce a tunnel "wave" shape under shallow flow conditions is dramatically less than that required under "natural" conditions, e.g., as indicated in Killen's 1980 article, the power required to produce operational natural waves is proportional to the height of the wave raised to the 3.5 power ($hw^{3.5}$). Consequently, a 2 meter wave would require 11.3 times the power of a 1 meter wave or approximately

3.7 mega watts or 4800 horsepower. An 8 cm in depth shallow flow wave as contemplated by the subject invention with similar width to Killen's structure would be able to produce a 2 meter high tunnel "wave" for under 400 horsepower.

(b) The capital costs and operating costs for shallow water tunnel "wave" generation is substantially less than deep water installations.

(c) The sight, sound, and sensation of tunnel "wave" riding is a thrilling participant and observer experience, that has heretofore only been available to relatively few people in the world. The subject invention will enable this experience to become more readily available.

(d) From a safety perspective, shallow water is generally perceived as safer in view of drowning.

<u>Operation of the Tunnel "Wave" Generator</u>

Fig. 5 illustrates Tunnel Generator 30 in operation with the concavity of front face 32 acting to shape a water walled tunnel from super-critical shallow water flow 39 within and upon which rider 41 can ride. Water flow 39 originating from a water source (not shown) moves in a direction 38 as indicated. At stem 31 water flow 39 moves over front face 32 and onto back surface (not shown). Back surface (not shown) is sufficiently smooth and with transitions analogous to a conventional waterslide such that rider 41 could safely be swept over or around Tunnel Generator 30 to a termination pool or area (not shown) to properly exit. Progressing from transition point 40 to stern arch 33 the horizontal and vertical concavity of front face 32 acts as a scoop to channel and lift water into the central portion of front face 32 towards stern arch 33. Combined with the attitude of Tunnel Generator 30 relative to the direction 38 of water flow 39, the resultant forces thereto propel water flow 39 along the path of least resistance which is upward and outward creating the desired tunnel 42. Tunnel 42 size is adjustable depending upon the velocity of water flow 39, i.e., the higher the flow velocity the larger the tunnel effect. The forward force component required to maintain rider 41 (including any skimming device that he may be riding) in a stable riding position and overcome fluid drag is due to the downslope component of the gravity force created by the constraint of the solid flow forming surface balanced primarily by momentum transfer from the high velocity upward shooting water flow 39. Rider's 41 motion upslope (in excess of the kinetic energy of rider 41) consists of the force of the upward shooting water flow 39 exceeding the downslope component of gravity. Non-equilibrium riding maneuvers such as cross-slope motion and

oscillating between different elevations on the "wave" surface are made possible by the interaction between the respective forces as described above and the use of the rider's kinetic energy.

Accordingly, it should now be apparent that Tunnel "Wave" Generator 30 embodiment of this invention can use shallow water flow in a water ride attraction to simulate ocean tunnel waves. In addition, Tunnel "Wave" Generator 30 has the following advantages:

- it requires a fraction of the energy utilized in generating a "real" wave;
- it costs substantially less to build and maintain;
- it allows a rider to experience the sight, sound, and sensation of tunnel wave riding, an experience that heretofore has not been available in commercial settings;
- it uses shallow water which is inherently safer than deep water in the prevention of drowning.

Description of Shallow Flow Inclined Surface

Turning now to Fig. 6, there is illustrated shallow flow inclined surface 44. Plan sectional lines as revealed in Fig. 6 are solely for the purpose of indicating the three dimensional shape in general, rather than being illustrative of specific frame, plan, and profile sections. Shallow flow inclined surface 44 is comprised of sub-surface structural support 45; back surface 46; and front face 47 which is bounded by an imaginary downstream ridge line 48, an upstream edge 49, and side edge 50a and 50b. Side edge 50 can have walls (not shown) or be connected with conventional broad surfaced downhill sliding transitions (not shown) to either contain or allow a rider to move out and off of the flow. Front face 47 can either be a gradual sloping inclined plane, a continuous concave planar surface, a concave planar surface joined to a convex planar surface, or preferably a combination of planar curved surfaces and planar inclined surfaces. Fig. 7 shows in cross-section a preferred profile of front face 47 with upstream edge 49 (indicated as a point in this cross-sectional view) as the upstream boundary and with a combination of curves and straight inclines as follows: concave curvature 51 as one moves upwards towards the downstream ridge 48 (indicated as a point in this cross-sectional view); concave curvature 51 transitioning to a straight incline 52 at a concave/straight transition point 53; straight incline 52 continuing to straight/convex transition point 55; and convex curvature 56 from straight/convex transition point 55 to downstream ridge 48. Back surface 46 joins front face 47 at the downstream ridge line 48. Back surface 46 is sufficiently smooth and

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with transitions analogous to a conventional waterslide such that a rider (not shown) could safely be swept over downstream ridge line 48 to a termination pool or area (not shown) to properly exit. Turning back to Figure 6, super critical water flow 39 originating from a water source (not shown) moves in direction 38 to produce a conforming upward flow over front face 47, the downstream ridge line 48 and onto the back surface 46 to form an inclined body of water upon which a rider (not shown) can ride. The outside dimensions of the flow forming front face 47 of shallow flow inclined surface 44 are capable of a broad range of values which depend more upon external constraints, e.g., financial resource, availability of water flow, etc., rather than specific restrictions on the structure itself.

The velocity of the water over shallow flow inclined surface 44 has a wide range, dependent upon the overall size of the inclined surface and the depth of water. In general, the flow is to be super-critical (i.e., according to the formula $v>\sqrt{gd}$ where v = velocity, g = acceleration due to gravity ft/sec^2, d = depth of the sheeting body of water). However, velocities in excess of that which is at a minimum necessary to achieve super-critical velocity are sometimes desired, e.g., to provide sufficient momentum transfer to support the weight component of a given rider, and to achieve the vertical heights required to form an unbroken "wave."

The depth of the water is primarily a function of that which is necessary to successfully operate for the purposes intended. Because of the operational requirements of momentum transfer, the depth of the water has direct relationship to the velocity of the water, i.e., the higher the velocity of flow, the lower the requisite depth. Since this embodiment is limited to shallow flows, the depth of water will range from approximately 2 to 40 centimeters.

Shallow flow inclined surface 44 can be fabricated of any of several of well known materials which are appropriate for the use intended. Concrete; formed metal, wood or fiberglass; reinforced tension fabric; air, foam or water filled plastic or fabric bladders; or any such materials which will stand the structural loads involved. A preferred embodiment includes a thick foamed plastic covering to provide additional protection for the riders using the facility.

Theoretically, no pool or water containment means is required for shallow flow inclined surface 44, in that the flow from a suitable flow source (e.g., pump and nozzle, fast moving stream or elevated reservoir/lake) is all that is required. However, where water recycling is preferred, then, low channel walls can be constructed to retain the flowing

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water with a lower collection pool, recycling pump and appropriate conduit connected back to the upstream flow source. The area of channel containment need be only large enough to allow the performance of appropriate water skimming maneuvers. Thus, such a structure could be constructed even in a back yard.

From the description above, a number of advantages of Shallow Flow Inclined Surface 44 becomes evident:

(a) The energy required to produce an unbroken "wave" shape similar to that simulated by Shallow Flow Inclined Surface 44 is dramatically less than that required under "natural" conditions, e.g., as indicated in Killen's 1980 article, the power required to produce operational natural waves is proportional to the height of the wave raised to the 3.5 power ($hw^{3.5}$). Consequently, a 2 meter wave would require 11.3 times the power of a 1 meter wave or approximately 3.7 mega watts or 4800 horsepower. An 8 cm in depth shallow flow wave as contemplated by the subject invention with similar width to Killen's structure would be able to produce a 2 meter high inclined surface "wave" for under 400 horsepower.

(b) The capital costs and operating costs for shallow water inclined surface "wave" generation is substantially less than deep water installations.

(c) The sight, sound, and sensation of inclined surface "wave" riding is a thrilling participant and observer experience, that has heretofore only been available to relatively few people in the world. The subject invention will enable this experience to be become more readily available.

(d) From a safety perspective, shallow water is generally perceived as safer in view of drowning.

Operation of Shallow Flow Inclined Surface

FIG. 8 illustrates Shallow Flow Inclined Surface 44 in operation. Super-critical water flow 39 originating from a water source (not shown) moves in direction 38 to produce a conforming upward flow over front face 47, the downstream ridge line 48 and onto the back surface 46 to form an inclined body of water upon which rider 41 can ride. Front face 47 serves as the primary riding area for rider 41. On this area rider 41 will be able to perform skimming maneuvers as follows: The forward force component required to maintain rider 41 (including any skimming device that he may be riding) in a stable riding position and overcome fluid drag is due to the downslope component of the gravity force (created by the constraint of sub-surface structural support 45) balanced primarily

by momentum transfer from the high velocity upward shooting water flow 39. The motion of rider 41 in an upslope direction (in excess of the kinetic energy of rider 41) consists of the force of the upward shooting water flow 39 exceeding the down slope component of gravity. Non-equilibrium riding maneuvers such as cross-slope motion and oscillating between different elevations on the "wave" surface are made possible by the interaction between the respective forces as described above and the use of rider's 41 kinetic energy. Back surface 46 is sufficiently smooth and with transitions analogous to a conventional waterslide such that rider 41 could safely be swept over downstream ridge line 48 to a termination pool or area (not shown) to properly exit.

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Accordingly, it should now be apparent that Shallow Flow Inclined Surface 44 embodiment of this invention can use shallow water flow in a water ride attraction to simulate unbroken ocean waves. In addition, Shallow Flow Inclined Surface 44 has the following advantages:

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- it requires a fraction of the energy utilized in generating a "real" wave;
- it costs substantially less to build and maintain;
- it allows a rider to experience the sight, sound, and sensation of continuous unbroken wave riding, an experience that hereto for has not been available in commercial settings. Such capability will greatly expand the training of beginning "surf-riders" and provide a venue for surf-camps, etc.

P1

- it uses shallow water which is inherently safer than deep water in the prevention of drownings.

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Description of Connected Structure

The Connected Structure creates additional surface area beyond the areas defined by Tunnel Wave Generator 30 and Shallow Flow Inclined Surface 44. In general terms, this expanded area can be described as a horizontal area upstream of the upstream edge of each respective embodiment. Furthermore, the Connected Structure describes specific ratios between three distinct regions that can be defined to exist on Tunnel Wave Generator 30 and Shallow Flow Inclined Surface 44 as improved by the Connected Structure. Through combination of area expansion and defined region size relationship, a flow forming means can be described with performance characteristics as yet undisclosed by the prior art.

Turning now to FIG. 9a, we see a generalized diagram of an improvement for a flow forming means herein called Connected Structure 57. Plan-sectional lines as revealed

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in FIG. 9a are solely for the purpose of indicating the three-dimensional shape in general, rather than being illustrative of specific frame, plan, and profile sections. Connected Structure 57 is comprised of a supra-equidyne area 58 which transitions (as represented by a dashed line 59) to an equilibrium zone 60, which in turn transitions (as represented by a dotted line 61) to a sub-equidyne area 62. The dimensions and relationship of Connected Structure's 57 sub-equidyne 62, equilibrium 60, and supra-equidyne 58 areas are described as follows:

FIG 9b illustrates a cross-section of Connected Structure 57, with sub-equidyne area 62, equilibrium zone 60, and supra-equidyne area 58 with a range of configurations 58a, 58b, and 58c that are capable of producing a flow that ranges from the previously described unbroken "wave" (i.e., inclined flow) and the tunnel "wave" flow.

The preferred embodiment for the breadth of the sub-equidyne area 62 in the direction of flow 38 is, at a minimum, one and one half to four times the vertical height (as measured from sub-equidyne to the top of supra-equidyne) of the total flow forming means. The large breadth would apply to low elevation means (e.g., 1 meter) and smaller breadth to high elevation means (e.g., 6 meters). Sub-equidyne 62 orientation is substantially horizontal and normal to the force of gravity.

The preferred embodiment for the shape of equilibrium zone 60 can be defined by a portion of a changing curve, e.g., an ellipse; parabola; hyperbola; or spiral. If a changing curve, the configuration of equilibrium zone 60 is substantially arcs of a closing curve (i.e., the ascending water encounters a decreasing radius as it ascends the face of the flow forming means). The radius of said closing curve being at its smallest approximating the radius of supra-equidyne 58 leading edge, and at its longest less than horizontal. For purposes of simplicity and scale (but not by way of limitation) the uphill breadth of equilibrium zone 60 can generally be defined by a distance approximately equal to the length of the rider's flow skimming vehicle, i.e., approximately three to ten feet.

The preferred embodiment for the shape of supra-equidyne area 58 can be defined by a portion of changing curve, e.g, an ellipse; parabola; hyperbola; or spiral. If a changing curve, the configuration of supra-equidyne area 58 is initially arcs of a closing curve (i.e., the ascending water encounters a decreasing radius as it ascends the face of the flow forming means). The radius of said closing curve is at its longest always less than the radius of the longest arc of equilibrium zone 60, and, at its smallest of sufficient size that a rider could still fit inside a resulting "tunnel wave". On the opposite end of the spectrum,

said arcs of a closing curve can transition, after a distance at least equal to 2/3's the length of the riders flow skimming vehicle (approximately two to seven feet), to arcs of an opening curve (i.e., the ascending water encounters an increasing radius as it ascends the face of the flow forming means). The only limitation as to the overall breadth of supra-equidyne area 58 in the direction of flow 38 is the practical limitation of available head of an upwardly sheeting flow.

Super-critical water flow 39 originating from a water source (not shown) moves in direction 38 to produce a conforming flow over sub-equidyne area 62, equilibrium zone 60, and supra-equidyne area 58 to form an inclined body of water upon which a rider (not shown) can ride and perform surfing or water skimming maneuvers that would not be available but for such Connected Structure 57.

<u>Operation of the Connected Structure</u>

The significance of Connected Structure 57 is a function of how it can be used to enable the performance of surfing and water skimming maneuvers. Essential to the performance of modern surfing and skimming maneuvers are the elements of oscillation, speed, and proper area proportion in the "wave" surface that one rides upon. Each element is elaborated as follows:

OSCILLATION: The heart and soul of modern surfing is the opportunity for the rider to enjoy substantial oscillation between the supra-critical and sub-critical areas. As one gains expertise, the area of equilibrium is only perceived as a transition area that one necessarily passes through in route to supra and sub critical areas. Oscillatory motion has the added advantage of allowing a rider to increase his speed.

SPEED: Speed is an essential ingredient to accomplish modern surf maneuvers. Without sufficient speed, one cannot "launch" into a maneuver. The method and means for increasing one's speed on a properly shaped wave face can be made clear by analogy to the increase of speed on a playground swing as examined in SCIENTIFIC AMERICAN, March 1989, p. 106-109. On a swing, if one is crouching at the highest point of a swing to the rear, ones energy can be characterized as entirely potential energy. As one descends, the energy is gradually transformed into kinetic energy and one gains speed. When one reaches the lowest point, one's energy is entirely kinetic energy and one is moving at peak speed. As one begins to ascend on the arc, the transformation is reversed: one slows down and then stops momentarily at the top of the arc. Whether one goes higher (and faster) during the course of a swing depends on what one has done during such swing. If

one continues to crouch, the upward motion is a mirror image of the downward motion, and ones center of mass ends up just as high as when one began the forward swing. If instead one stands when one is at the lowest point, i.e., "pumping" the swing, then one would swing higher and faster.

The importance of sub-equidyne area 62 in the context of the previous discussion of swing dynamics, is that sub-equidyne area 62 is by its nature the lowest point on Connected Structure 57 and on a wave. Standing/extending at this low point results in a larger increase of speed than if one stood at any other point on Connected Surface 57 or on a wave. This increase in speed and total kinetic energy is due to two different mechanistic principals, both of which may be utilized by a rider on Connected Structure 57 or a wave. By standing at the lowest point in the oscillatory path, the center of gravity of the rider is raised allowing a greater vertical excursion up the slope than the original descent. Crouching at the top of the path and alternately standing at the bottom allows an increase in vertical excursion and restoration of energy lost to fluid drag. Additionally, the other mechanism, increasing the kinetic energy, is due to the increase in angular rotation. As the rider in his path rotates around a point located up the wave face, extension/standing at the low point increases his angular velocity much in the same manner as a skater by drawing in his/her arms increases his/her rotational speed due to the conservation of momentum. However, kinetic energy increases due to the work of standing against the centrifugal force and because kinetic energy is proportional to the square of angular velocity, this increase in kinetic energy is equivalent to an increase in speed.

PROPER AREA PROPORTION: Connected Structure 57 as a flow forming surface combines in proper proportion the sub-critical 62, equilibrium 60, and supra-critical 58 areas so as to enable a rider to oscillate, attain the requisite speed and have available the requisite transition area for performance of modern day surfing and skimming maneuvers that would not be possible, but for said Connected Structure 57.

Turning to Figure 10 there is illustrated a surfer 63 on an inclined surface as improved by Connected Structure 57 in various stages of a surfing maneuver. Surfer 63 is in a crouched position on supra-equidyne area 58 and gathering speed as he moves downward over a conformed sheet of super-critical water flow 39 which originates from a water source (not shown) and moves in direction 38. Upon reaching the low point at sub-equidyne area 62, surfer 63 extends his body and simultaneously carves a turn to

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return to supra-equidyne area 58. As a consequence of such maneuvering, surfer 63 will witness an increase in speed to assist in the performance of additional surfing maneuvers. The process by which a surfing or water skimming rider can actively maneuver to increase his speed is referred to as the Acceleration Process.

<u>Description of Self-Clearing Incline and Tunnel Wave</u>

Turning to FIG. 11a (isometric view) and FIG. 11b (cross-sectional view) there is illustrated a top vent self-clearing incline improvement for Shallow Flow Inclined Surface (as improved by Connected Structure) all of which is hereafter referred to as a Self-Clearing Incline 64. Self-Clearing Incline 64 is comprised of Shallow Flow Inclined Surface as modified by lowering the elevation of side edge 50b' and causing downstream ridge line 48 to incline from the horizontal. FIG. 11b superimposes a cross-sectional profile of side edge 50a over the lowered side edge 50b'. To have a noticeable effect, the angle of inclination should be a minimum 5 degrees.

Turning to FIG. 12 (contour map) there is illustrated a swale self-clearing incline improvement for Tunnel "Wave" Generator 30 (as improved by Connected Structure 57) all of which is hereafter referred to as Self-Clearing Tunnel Wave 66, comprised of sculpting from front surface 32, sub-equidyne area 62 and structural matrix support 37 (not shown) a shallow venting swale 65. All surfaces of swale 65 are smooth and without edges.

<u>Operation of Self-Clearing Incline and Tunnel Wave</u>

Self-Clearing Incline 64 and Self-Clearing Tunnel Wave 66 are designed to prevent unwanted turbulent white water build-up that fails to clear from the riding surface in the usual manner of "washing" over the downstream ridge of these respective embodiments. In practice, this vent problem will only occur if there is a restriction on flow venting to the side of the inclined surface or generator, e.g., a channel wall, or where there is a tremendous amount of activity, e.g., multiple riders on the surface of the water.

This undesirable build-up is particularly acute in an upward directed flow. This build-up will most likely occur during three stages of operation, (1) water flow start-up with no rider present; (2) transferring the kinetic energy of high speed water flow to a maneuvering rider; and (3) cumulative build-up of water due to a spilling wave. In the start-up situation (1), due to the gradual build up of water flow associated with pump/motor phase in or valve opening, the initial rush is often of less volume, velocity or pressure than that which issues later. Consequently, this initial start water is pushed by the stronger flow, higher pressure, or faster water that issues thereafter. Such pushing

results in a build-up of water (a hydraulic jump or transient surge) at the leading edge of the flow. An upward incline of the riding surface serves only to compound the problem, since the greater the transient surge, the greater the energy that is required to continue pushing such surge in an upward fashion. Consequently, the transient surge will continue to build and if unrelieved will result in overall flow velocity decay, i.e., the slowed water causes additional water to pile up and ultimately collapse back onto itself into a turbulent mass of bubbling white water that marks the termination of the predominantly unidirectional super-critical sheet flow. In the situation of kinetic energy transfer (2), when a maneuvering rider encounters faster flowing water or water that is moving in a direction different than the rider, a transient surge builds behind or around the rider. Likewise, if this transient surge grows too large it will choke the flow of higher speed unidirectional super-critical sheet flow, thus, causing flow decay. In the situation of an excessive build up of water over time from a spilling wave (3), the interference of a preceding flow with a subsequent flow can result in an undesired transient surge and flow decay at a point near where the two flows meet. Under all three conditions, it is possible to control or eliminate the transient surge by immediately increasing the flow pressure and over-powering or washing the transient surge off the riding surface. However, there comes a point where the build-up of water volume is so great that for all practical purposes over-powering is either impossible, or at best, a costly solution to a problem capable of less expensive solution. Such less expensive solution is possible by the introduction of vents.

Two classes of vent mechanisms are identifiable. The first class, self-clearing inclines, are used to clear transient surges from inclined surfaces. FIG. 13a, 13b, and 13c show in time lapse sequence how the design of self-clearing incline 64 operates to solve the problem of a pressure/flow lag during start-up. In FIG. 13a water flow 39 has commenced issue in an uphill direction from water source (not shown) in direction 38. As water flow 39 moves up front surface 47, the leading edge of water flow is slowed down by a combination of the downward force of gravity and friction with front surface 47, whereupon, it is overtaken and pushed by the faster and stronger flow of water that subsequently issued from the water source. The result of this flow dynamic is that a transient surge 68 begins to build. However, as transient surge 68 builds, it reaches the height of low side edge 50b' and commences to spill over onto back surface 46. FIG. 13b shows this start procedure moments later wherein the water pressure/flow rate from the water source has increased and transient surge 68 has moved further up the incline. FIG

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13c shows the final stage of start-up wherein the transient surge has been pushed over the top of Down Stream Ridge Line 48 and water flow 39 now runs clear. Similar to the start-up procedure, when a lower speed rider encounters the higher speed water, or when an accumulative build-up of water results from a spilling wave, a transient surge may occur. In like manner, the transient surge will clear by spilling off to the lowered side accordingly.

The second class of vent mechanism, swale vents, are used to assist in clearing transient surges from tunnel wave generators. FIG 14a and 14b show in time lapse sequence how the design of swale 67 operates to solve identical problems as suffered by the inclined surfaces with channel walls. In FIG. 14a water flow 39 has commenced issue in an uphill direction from water source (not shown) in direction 38. Transient surge 68 begins to build. However, as transient surge 68 builds, it commences to vent into swale 67, thus, permitting tunnel wave 42 to properly form as shown in FIG. 14b.

CL Description and Operation of the Omni-Wave

P FIG. 15 depicts a preferred embodiment herein named an Omni-wave 69 comprised of Self-Clearing Incline 64 which is interconnected and continuous with Self-Clearing Tunnel Wave 66.

FIG. 16a, FIG. 16b, FIG. 16c, FIG. 16d, FIG. 16e and FIG. 16f illustrates Omni-Wave 69 in operation. A unique feature of Omni-Wave 69 is its unique flow forming shape can permit (by way of a progressive increase of the net head of the water flow) the transformation of super-critical water flow 39 that originates from a water source (not shown) in direction 38 to a stationary spilling wave 70 along the entire forming means (as illustrated in FIG 16a); to a stationary spilling wave 70 with Self Clearing Incline 64 flow (as illustrated in FIG 16b); to a Self-Clearing Incline 64 and Self-Clearing Tunnel Wave 66 flow (as illustrated in FIG 16c). This progressive wave forming method is hereinafter referred to as the "Wave Transformation Process". The Omni-Wave and the Wave Transformation Process will offer an improved environment for the performance of surfing and water skimming maneuvers. FIG. 16d shows surfer 63 and rider 41 on Self-Clearing Tunnel Wave 66 and Self-Clearing Incline 64 respectively. FIG. 16e shows surfer water skimming kneeboarder riding upon stationary spilling wave 70, FIG. 16f shows inner-tube rider 72 and water skier 73 on stationary spilling wave 70 and Self-Clearing Incline 64 respectively.

CL Description and Operation of the Fluid Half Pipe

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Turning to FIG. 17 wherein an apparatus is revealed that will enable riders to perform surfing and water skimming maneuvers in a format heretofore unavailable except by analogy to participants in the separate and distinct sports of skateboarding and snowboarding, to wit, half-pipe riding. Fluid Half-Pipe 74, comprises a method and apparatus for generating a body of water 80 with a stable shape and an inclined surface thereon substantially in the configuration of a half-pipe with the opening of said half-pipe facing in an upwards direction. The water 81 which supplies said body of water flows over the leading edge 82 of the half-pipe flow forming means 89 and down one side (hereinafter referred to as the down-flow-side 83), in a direction perpendicular to the length of said half-pipe, across an appropriate sub-equidyne flat section 84, and up and over the other side of the half-pipe (hereinafter referred to as the up-flow-side 85), across the trailing edge 86, and into an appropriate receiving pool 87 or other suitably positioned Fluid Half Pipe or attraction. A rider 88a enters the flow at any appropriate point, e.g., sub-equidyne flat section 84, wherein as a result of his initial forward momentum of entry, the excessive drag of his water-skimming vehicle, and the added drag of the riders weight induced trim adjustments to his riding vehicle, said rider (now 88b) is upwardly carried to a supra-critical area in the upper regions of up-flow-side 85 near the half pipe's trailing edge 86, wherein as a result of the force of gravity in excess of the drag force associated with the riding vehicle and the riders own weight trim adjustments to reduce drag, rider (now 88c) hydro-planes down the up-flow-side 85, across the sub-equidyne flat 84, and performs a turn on down flow side 83 to return to up-flow-side 85 and repeat cycle.

As can be appreciated by those skilled in the art, Fluid Half-Pipe 74 will offer its participants a consistent environment in which to perform known surfing and water skimming maneuvers, and due to the combination of up-side-flow, flat, and down-side-flow a unique environment in which to perform new maneuvers unachievable on existing wave surfaces.

The preferred embodiment for the breadth of the flow forming means 89 of Fluid Half-Pipe 74 approximates Connected Structure 57 joined to its mirror image at the midpoint of sub-equidyne 62. It is preferred that said width remain constant for the length of flow-forming means 89, however, variations in width with resultant variations in cross-sectional shape are possible. The limitations on minimum and maximum width is a function of ones ability to perform surfing and water skimming maneuvers. If the flow forming means is too narrow, a rider would be unable to negotiate the transition from the

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up-flow side 85 to the down-flow-side 83 or vice versa. If too wide, a rider would not be able to reach or utilize the down-flow side 83 to perform surfing and water skimming maneuvers.

A preferred embodiment for the length of the flow forming means of Fluid Half Pipe 74 is at a minimum a length sufficiently wide to perform surfing and water skimming maneuvers thereon, and at a maximum a function of desire and/or budget.

A preferred embodiment for the cross-sectional shape of the up-flow side's flow forming means has been shown in FIG. 9b and discussed above. FIG. 9b illustrated a detailed cross-section of Connected Structure 57, with sub-equidyne area 62, equilibrium zone 60, and supra-equidyne area 58. Caution must be taken in the design of the up-flow side 85 supra-equidyne area to insure proper water flow up and over the trailing edge 86. Excessive steepness or height that results in untimely or improperly located spilling or tunneling waves can result in an excessive build-up of turbulent white water in the sub-equidyne flat area 84 which may culminate in complete deterioration of the up-side-flow. However, since advanced riders, in order to maximize speed and perform certain maneuvers, e.g., aerials, prefer a steep supra-critical area that approaches or exceeds vertical then it is preferred that spilling or tunnel wave formation (if any) be limited to areas adjacent the side openings of half-pipe 74, and that the majority middle half pipe 74 be substantially the shape as illustrated in FIG. 9b with supra-equidyne configuration 58a.

Generally, the elevation of half-pipe 74 leading edge 82 will exceed its line-of-flow position on half-pipe 74 trailing edge 86. This differential in elevation will insure that the water of said body of water 81 will have sufficient dynamic head to overcome all internal and external friction that may be encountered in its circuit down, across, up, and over flow forming means 89. The preferred ratio by which the down-flow-side exceeds the up-flow side ranges from a minimum of ten to nine to a maximum of ten to one. It is also preferred that the respective leading and trailing edge 82 and 86 remain at constant elevations along the length of the half-pipe. Variations in elevation are possible, however, source pool water 81 dynamics, receiving pool water 87 dynamics, and maintenance of line of flow dynamic head must be accounted for.

In cross-sectional profile, a standard configuration for Fluid Half Pipe 74 is illustrated in FIG. 18a. In this standard configuration the cross-sectional elevation, width, and depth remains constant for the length of half-pipe 74. FIG. 18b illustrates an asymmetrical configuration, wherein, the leading and trailing edges 82 and 86 remain at

constant elevations and the width between trailing edges remains constant, however, the distance between trailing edges and the flat sub-equidyne section 84 continues to increase at a constant rate of fall. The object of this particular asymmetrical embodiment is to increase throughput capacity for half-pipe 74 as the result of rider movement in the direction of fall due to the added vector component of gravity force ascribed to the weight of the rider in the direction of fall.

The preferred velocity of water in the subject invention is substantially a function of the overall drop in distance from leading edge 82 to the flat area 84. Consequently, previously discussed preferences in the overall height of the Connected Structure dictate 3 the preferred water velocity. Such velocity can be calculated in accordance with Bernoulli's 29,b equation $v=\sqrt{2gz}$ where v is the velocity in feet per second, g is gravity ft/sec^2 and z = vertical distance dropped in feet.

The preferred depth of water is that which is required to perform surfing and water skimming maneuvers. For purposes of Half Pipe 74 the minimum depth is 2 cm. and the maximum depth is whatever one might be able to afford to pump. Except B the desirable spilling/tunnel wave formation adjacent a side-opening of half-pipe 74, an additional preference is that the water avoid excessive turbulence that results from a hydraulic jump which occurs when the velocity of a sheeting body of water exceeds a certain critical velocity at a certain minimum depth.

Variations in the breadth and longitudinal movement of the body of water that flows upon the half-pipe can result in enhancements to rider through-put capacity for the Fluid-Half Pipe. FIG. 19 depicts a half-pipe configured flow forming means 89. A stably shaped body of water 80a is situated on one side 89a of said flow forming means. The water 81 which supplies said stably shaped body of water is limited by a dam 91a to just one-half of the flow forming means 89. Riders 88a, b, c and d enter the flow at any appropriate point., e.g., the sub-equidyne flat section 84 and perform water skimming maneuvers thereon. As shown in FIG. 19, the water skimming maneuvers are performed using an inner-tube type vehicle. After an elapsed period of time, e.g., several minutes, a dam 91b is positioned to block the water 81 which supplies the stably shaped body of water 80a on side 89a of said flow forming means. Upon blockage of the source of water, the stably shaped body of water 80a soon ceases to exist on side 89a of said flow forming means. Consequently, the riders 88a, b, c and d drift to the sub-equidyne section 84 and can easily exit. Simultaneously with, or shortly after the blockage by dam 91b, dam 91a

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opens and water 81 begins to flow over flow forming means 89b, whereupon forming a stably shaped body of water 80b that remains situated on side 89b. Riders 88e, f, and g enter the flow and commence to perform water skimming maneuvers for their allotted time span, whereupon dam 91a is re-positioned and the cycle is set to repeat.

FIG. 20 illustrates super-critical water flow 39 originating from a water source (not shown) moving in direction 36 to produce a conforming upward flow over front face 78. Dividers 79 provide separation for the individual riders 77a, 77b, and 77c and to prevent a "jet wash" phenomenon that can result in loss of a rider's flow. This "jet wash" phenomenon occurs when a rider who is positioned in the equilibrium or supra-equidyne area of a thin sheet flow gets his flow of water cut off by a second rider positioned with priority to the line of flow. The cutting off of water occurs in thin sheet flow situations due to the squeegee effect caused by the second rider's skimming vehicle.

As will be recognized by those skilled in the art, certain modifications and changes can be made without departing from the spirit or intent of the present invention. For example, the curvatures given as examples for the Connected Structure do not have to be geometrically precise; approximations are sufficient. The same is true of limits in angles, radii and ratios. The temperature and density of the water will have some difference although the range of temperatures in which surfer/riders would be comfortable is fairly limited.

The terms and expressions which have been employed in the foregoing specifications are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described, or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

CM I claim:

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